MODULE

TEACHING OF CHEMISTRY
(Classes XI-XII)

FOR

Master Trainers/Teachers
(INSET Programme)

Directorate Of Curriculum & Teacher Education N.W.F.P Abbottabad

February 2003

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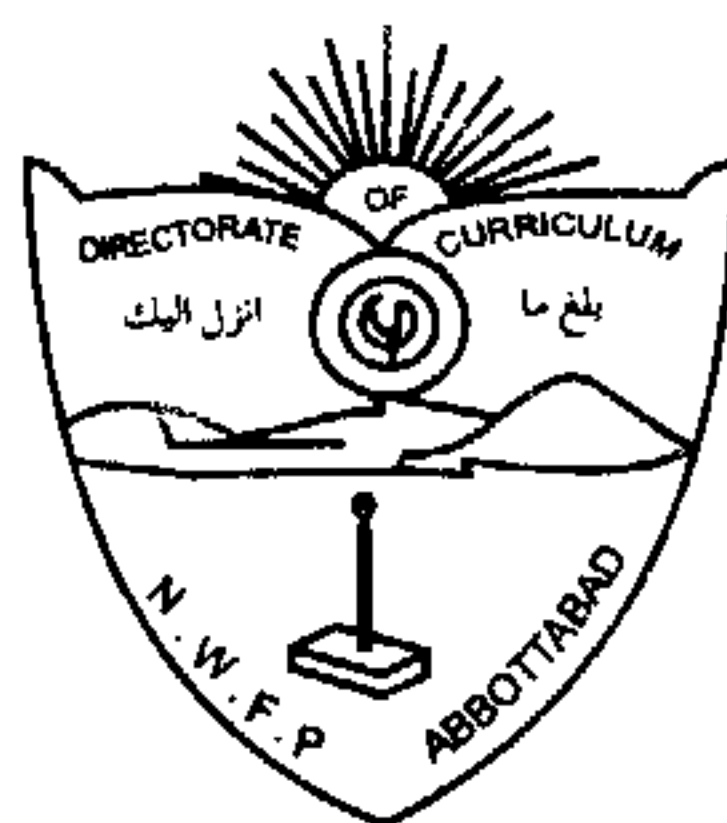
Directorate Of Curriculum & Teacher Education N.W.F.P Abbottabad

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Title:-	**Module Teaching of Chemistry Class XI-XII For Master Trainers/Teachers (INSET Programme)**
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Errata for Teaching Module of Chemistry for classes XI-XII

S.No.	Page Number	Line Number	In-correct sentence	Correct sentence
1	26	9	-	is
2	33	5	Define	Definite
3.	33	7	From	Form
4.	35	14	Salphate	Sulphate

FOREWORD

Directorate of Curriculum & Teacher Education, NWFP, Abbottabad is launching a comprehensive programme of in-service teachers training through out the province for all subjects/categories for the classes 6th to 12th under the title "Teacher Training Programme" scheme Improvement of Learning Environment For Quality Improvement for the year 2002-2004 as per policy of the Govt of NWFP, School & Literacy Department, Peshawar. The prime focus of this manual is training delivery effectively. There are two approaches to teacher's professional development, the carport approach and the individual one, but in this guide book attempts are made to link the both practically.

To make the INSET Programme more effective and successful a "Survey Study" has been conducted to collect the feed back, needs of the learners, requirements of the teaching staff and desires of the concerned managers through, interview/questionnaires, survey form and classroom observation forms. Sample for the study was selected a few middle and secondary/Higher Secondary schools (Girls boys urban & rural).

The study was conducted by the Deputy Director (Training) and Subject Specialists of this Directorate.

In the light of above information & facts training strategy and instructional material has been developed to improve the learning environment for quality improvement through the innovative methodology and pedagogical techniques.

Instructional material consists on training manual for lead trainers & field trainers for delivery of training effectively and modules for all subjects for the classes VI–XII in Science/Arts to facilitate the field Trainers as well as trainees of all categories (SS, SET (Science/Arts), CT, AT, TT).

The training manual comprises two parts, one for Subject Specialists training imparted by PITE and the other one for SET/CT/AT/TT training imparted by RITEs NWFP.

Umar Farooq
Director
Curriculum & Teacher Education
NWFP, Abbottabad

OBJECTIVES OF MODULE.

The present Module has been targeted to:-

1. Provide a guideline for PITE staff in imparting training to subject specialist in a new situation.

2. Help in the in-service teacher training of subject specialist in chemistry throughout NWFP.

3. Introduce the working subject specialist of Chemistry with Activity Based Learning for meaningful and quality education.

4. Guide the working subject-specialist of chemistry for planning of their daily lessons according to the spirits of activity based learning.

5. Localize the concept of chemistry and appreciate their role in our daily life.

CONTENTS.

1. Introduction of Module.
2. Atomic Mass and Atomic Mass Unit.
3. Mole and its importance
4. Real gases and their deviation from ideal gas behaviour.
5. Crystal and crystal systems.
6. pH-Scale, its importance and Measurement.

INTRODUCTION OF MODULE

Chemistry is a philosophical and experimental science, which deals with the study of various aspects of matter. These different aspects of matter may include the composition, the structure and the properties of matter, the various types of changes taking place in matter and various principles and laws relating to matter.

As far as matter is concerned, it is something, which occupies space and has mass and weight. As such every thing in this universe including our selves is material in nature, and its philosophical and scientific study is chemistry. This fact in itself explains the importance of chemistry.

Although chemistry is a very important branch of knowledge and play a very crucial role in our day-to-day life. Yet it is not making as strong roots in our country as are required. The chemistry students as well as the teachers are facing many problems while dealing with this subject. The problems are of diverse nature and relate to teaching, training, non-involving atmosphere, understanding and concept formation and last but not the least i.e. the practical application of the subject in our daily life. Such problems are notable especially at secondary and higher secondary levels.

Among these diverse problems and difficulties, the lack of understanding and concept formation in chemistry students so as to lead them for practical application of the subject need special mention. This problem is the direct consequence of the prevailent teaching methodologies. It has been observed that although, our teachers have command over the subject matter and work very hard in imparting knowledge to the students. But the present methodologies and teaching strategies have proved to be non-effective and non-motivational since there is a general unrest among the chemistry students and their parents. We have not been able to achieve the objective of quality education in conceptual context.

Researches have revealed that quality and conceptual education is best possible through, activities based learning. Learning by doing and involvement, as propounded by Jean Jacqueous Rousseau, is more effective. It is now an established fact that directed activities give reality to learning.

Activities are meant to provide varied experiences to the learners to facilitate the acquisition of knowledge, experience, skills and attitudes.

The principles of an experimental science like chemistry should be learnt by keen observations and experimentations. This is possible only if teachers and students are subjected to practical involvement in the content of chemistry. They can be practically involved in the subject only through directed activities. This activity based learning would help in the establishment of stimulating environment for creative expression.

Keeping in view these ground realities, the Directorate of Curriculum and Teachers Education, NWFP Abbottabad with the consent of Education Department, Govt. of NWFP, has initiated a noble venture of developing Modules for providing guidelines to teacher's training on these patterns. The first phase of this venture, under the dynamic leadership of Deputy Director, Shameem Sarfaraz, is over in the shapes of developed modules in various subjects. The present module of chemistry is one among these developed modules.

Five concepts of chemistry have been selected as model lessons for activity based learning in this module and includes:-

1. Atomic mass and Atomic Mass unit.
2. Mole and its importance.
3. Real gases and their deviation from ideal gas behaviour.
4. Crystal and crystal systems.
5. PH-Scale, its importance, and measurement.

The rationale behind selecting these basic and fundamental topics of chemistry is their conceptual nature.

Although these topics seem very simple for lecture method and ordinary teaching but their subjection to activities was a difficult and cumbersome task. By the grace of God, who gave me strength and ideas, I tried my best to present these topics in a manner so that the learners are involved to a maximum level in these and their learning experiences become more meaningful and effective. It is hoped that various activities designed would prove beneficial in concept formation of these topics.

The present module should not be considered an end in itself. It has been developed to provide a guideline only, for the most experienced subject specialists in chemistry who, off course, know much more about the subject. Although it covers only five concepts, but it is expected that this minor work may start a chain reaction for the activity based learning in the subject of chemistry. It is hoped that Master Trainers/Teachers will develop many more important concepts on these lines during and after the training workshops thus present the subject matter of chemistry in a more simple, logical, motivational and inspirational way. Good luck to you in your expected new journey.

LESSON NO.1

Concept:-

Atomic Mass and Atomic Mass Unit.

Objectives:- At the end of the lesson, the students will be able to:-

1. Know the meaning of Atomic Mass.
2. Define relative Atomic Mass.
3. Understand Atomic Mass Unit.
4. Calculate atomic Mass unit in terms of grams.
5. Calculate Relative Atomic Masses of various elements.

Materials Required.

1. Periodic Table
2. Black Board
3. Chalk
4. Teacher Made work sheets (5 Copies)
5. Play Cards (i). 1 set (5 cards) will have No of protons and Neutrons of different atoms (ii) Another set will have No. of isotopes, masses and abundance of these)

Subject Matter/Contents.

Atomic Mass:-

Atoms are so tiny particles that their absolute masses are difficult to be measured. It is impossible to place a single atom on any analytical balance and directly determine its mass. However, the masses of different atoms can be compared with each other by measuring the mass of one element taken as a standard. In this way the relative masses of elements can be obtained. In 1961, scientists all over the world agreed to make the most abundant variety of carbon as a standard because it enters into many chemical combinations. A carbon atom that is made up of 6 protons,6 Neutrons and 6 electrons has been arbitrarily defined to have an atomic

mass of exactly 12 atomic mass units. Accordingly atomic mass may be defined as:

"The average mass of various Isotopes of an element as compared with the mass of an atom of carbon taken as 12:00".

Since Atomic masses depend upon the number of possible isotopes and their natural abundance, this is why these have usually got fractional values e.g. Atomic mass of chlorine (cl) = 35.5 and Hydrogen (H) = 1.008.

Atomic mass is a ratio, therefore it has no specific unit. We can use any unit of mass or weight to express atomic Masses i.e, grams, Kilograms, Tons, Pounds etc. However, a more convenient and agreed way of expressing atomic masses is in terms of Atomic Mass units (a.m.u).

ATOMIC MASS UNIT.

The scientists, all over the world, usually agree to express atomic masses in terms of Atomic Mass units (a.m.u). Atomic Mass unit is defined as a mass exactly equal to one-twelfth ($1/12^{th}$) the mass of one carbon-12 atom(${}_6C^{12}$)

1 a.m.u. = $1/12^{th}$ the mass of C-12

AS 1 mole of C = 6.02×10^{23} atoms:
And Atomic Mass of carbon = 12 grams = 1 mole.

So, 6.02×10^{23} atoms of carbon weighs = 12 grams of C

1 atom of carbon weighs = $12/6.02 \times 10^{23}$

= 1.99×10^{-23} grams

Therefore:

1. a.m.u = $1/12 \times 1.99 \times 10^{-23}$ grams.

1 a.m.u = 1.66×10^{-24} grams.

Calculation of Relative Atomic Masses.

The relative Atomic Masses are calculated by the following expression:

Relative Atomic Mass = $\frac{\text{Mass of Isotope-1xAbundance +Mass for Isotope-2xAbundance.}}{100}$

Example:-

1. Relative Atomic Mass of Neon:-

   Neon has 3 Isotopes as:-

$_{10}Ne^{20}$	Abundance =	90.92 %
$_{10}Ne^{21}$	Abundance =	0.26 %
$_{10}Ne^{22}$	Abundance =	8.82 %

Average Atomic Mass = $\frac{20x90.92+21x\ 0.26+22x8.82}{100 \text{ atoms}}$

= 20.179

Thus the Relative Atomic Mass of Neon (Ne) = 20.179 amu /Atom

2. Relative Atomic Mass of Copper:- Copper has two Isotopes as:

$_{29}Cu^{63}$	Abundance =	69.09 %
$_{29}Cu^{65}$	Abundance =	30.91 %

Average Atomic Mass = $\frac{62.93x69.09+64.93x30.91}{100 \text{ Atoms}}$

= 63.55

Thus the relative atomic Mass of copper(Cu)= 63.55 amu/atom

METHODOLOGY

Activity No.1 (Concept of Atomic Mass):

For brain storming, ask the following questions from students.

1. What is Matter?

 Expected Ans: Any thing which has volume and Mass/weight.

(ii) What is an atom?

 Expected Ans: The smallest particle of Matter (Element).

1. Do atoms have Mass?

 Expected Ans: Yes, because is matter.

2. How would you measure the masses of Atoms?

 Expected Ans By adding the Number of Protons and Neutrons.

(v) At this stage, write down the following expression on black board.

 Atomic Mass = Number of Protons + No. of Neutrons.

1. Divide the class in to 5 Groups
2. Distribute play-cards into each group. The cards will show number of Protons and Neutrons of various atoms. Each card should have these values for at least three atoms.
3. Ask each group to find the atomic masses of given atoms from the respective No. of protons and neutrons.
4. Monitor and help the groups while doing their work.
5. Ask each group to write down their work on the black board. Each group should nominate a single student for presentation of their work.
6. At the end, generalize the responses of all group works.

Activity No.2 (Definition of Atomic Mass).

1. Write down on blackboard at least 3 atomic masses of atoms which have fractional values such as chlorine (Cl) =35.5; Hydrogen (H) = 1.008 and Boron (B) =10.81
2. Ask the following questions from students: -

 (a) Can Protons and Neutrons have fractional values?

 Expected Ans: - No.

 Note: - If the students are confused, discuss your question with them and make your question clear.

 (b) Why the atomic Masses/weights have fractional values?

Expected Ans: Nil, student confused.

(c) Ok, well, can I ask the definition of an Isotope?

Expected Ans: Yes, Atoms of the same element which have different atomic Masses.

3. Repeat the definition of Isotope and write on blackboard as:
" Atoms of the same element having same atomic Number but different atomic Mass "OR" Atoms of the same element having different Number of Neutrons".
1. At this stage, instruct the class that Atomic Masses have fractional values because these are comparative masses/weights calculated on the basis of carbon-12 atom choosen as a standard.
2. Write down the definition of Atomic Mass on blackboard as: -
"The average mass of all the Isotopes of an element as compared to the mass of an atom of carbon arbitrarily taken as 12.00 amu ($_6C^{12}$)".
6. Ask the students to note-down this definition in their notebooks. Instruct the class about the historical back ground and reasons as reported in the contents.

Activity No.3 (Atomic Mass Units)

Ask the following question from students:

1. Can you see an atom with a naked eye?
Expected Ans: - No
2. Can anyone of you measure an atom on a balance?
Expected Ans: - No
3. In which units mass is usually measured?
Expected Ans: Grams, Kilograms, Tones, Pounds etc.
4. Based upon the last question, tell the class that though Atomic masses could be measured in grams, kilograms and tones etc, but a more convenient way is in terms of Atomic Mass Units.
5. Elaborate the definition of Atomic Mass Unit to class and write down on black board as follows: -
" Atomic Mass Units is defined as a mass exactly equal to one- twelfth ($1/12^{th}$) the mass of one carbon-12 atom ($_6C^{12}$) choosen as a standard.
1 a.m.u $=1/12^{th}$ the mass of carbon-12.
6. Ask the students to note down the definition.

Activity No.4 (Calculation of Atomic Mass Unit in Grams)

1. Provide a teacher made work sheet to each group containing the following blank items.

WORKSHEET.

1 amu =___ th the mass of C-12
As 1 mole of C-atom contains =_______ atoms of carbon
And Atomic weight of Carbon =________ grams
So,
6.02x1023 atoms of _________ weighs = 12 grams of carbon
1atom of carbon weighs = _______grams.
6.02×10^{23}
1atom of carbon =_____________ grams
Therefore
1amu= 1/12x________ grams
1Amu =________ grams.

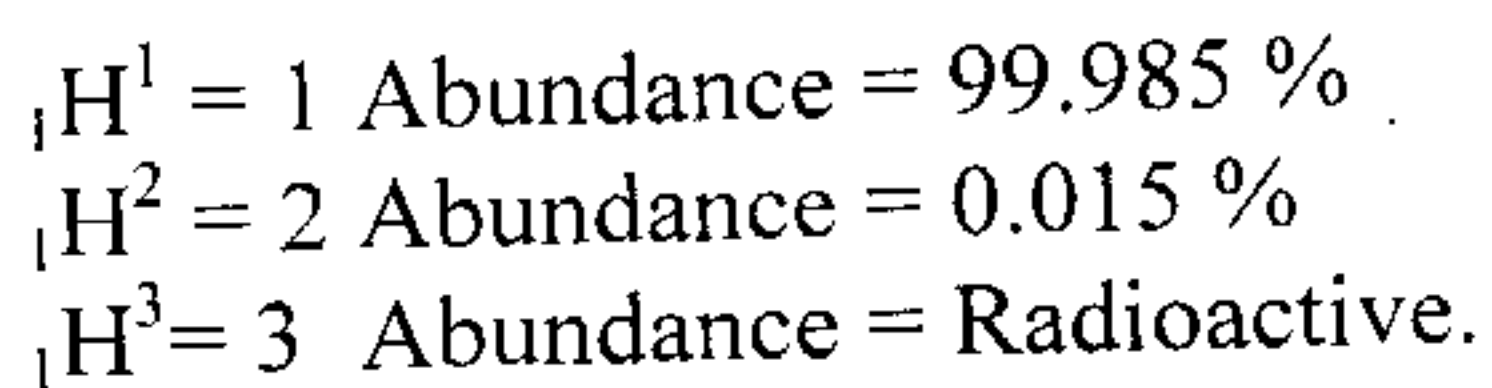
2. Ask each group to complete the blank items.
3. Monitor and instruct each group while doing their assigned work.
4. When the groups complete their work, ask them to report on blackboard.
5. Avoid the repetition of students representation i.e. the same student should not dominate and represent a particular group time and again. Give chance to different students for representation of groups.
6. Ask the group presenters to write their report neatly and leave space for other group reports so that all five-group reports are present on blackboard at the same time.
7. When all the groups have reported their work on blackboard, tick the correct blanks.
8. Generalize and write on blackboard as written in the contents.
9. Ask the students to write down this relationship in their notebooks.

Activity No.5 (Calculation of Relative Atomic Masses): -

1. Write down the heading "Calculation of Relative Atomic Masses" on blackboard.
2. Ask the students that the relative Atomic Masses are calculated by the expression: -

$$\text{Relative Atomic Mass} = \frac{\text{Mass of Isotope-1x Abundance + Mass of Isotope-2 x Abundance}}{\text{100 (Atoms)}}$$

3. Write this expression on blackboard.
4. Distribute play cards in each group.
5. Each play card will have all the Isotopes of an element, along their masses and natural abundance Percentage.
6. The elements and their Isotopes may include: -

a) **Hydrogen** 3 Isotopes.

$_1H^1$ = 1 Abundance = 99.985 %
$_1H^2$ = 2 Abundance = 0.015 %
$_1H^3$= 3 Abundance = Radioactive.

b) **Chlorine: -** 2 Isotopes.

$_{17}Cl^{35}$ = 35 Abundance = 75.53 %
$_{17}Cl^{37}$ = 37 = 24.47 %

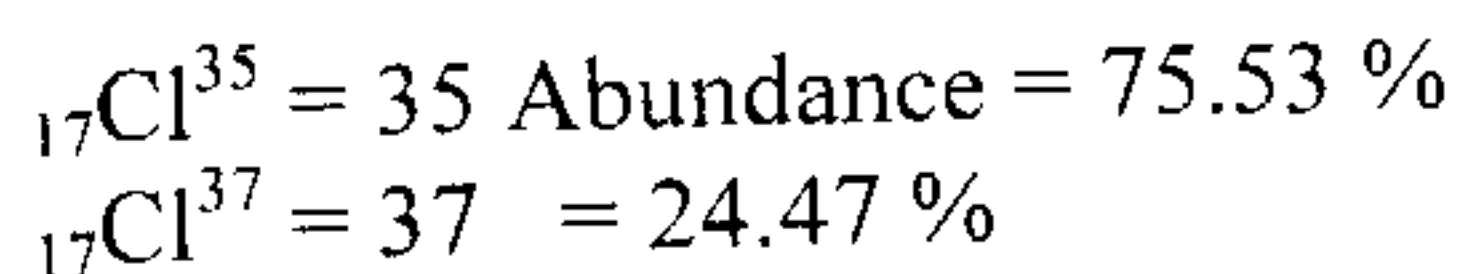
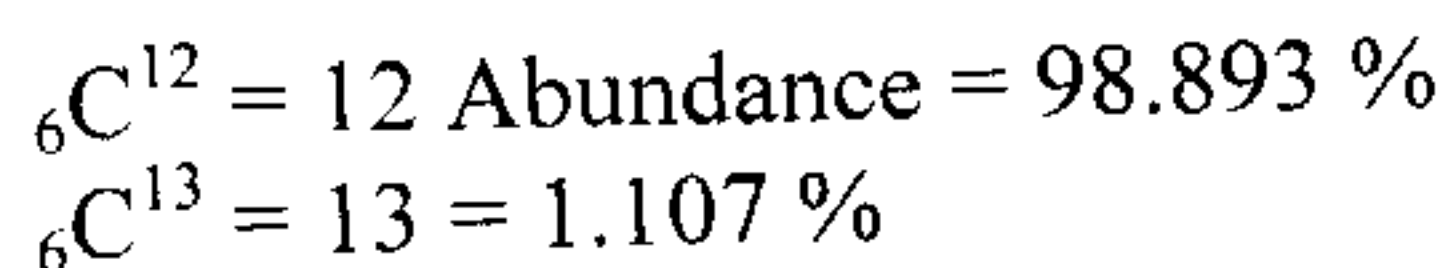
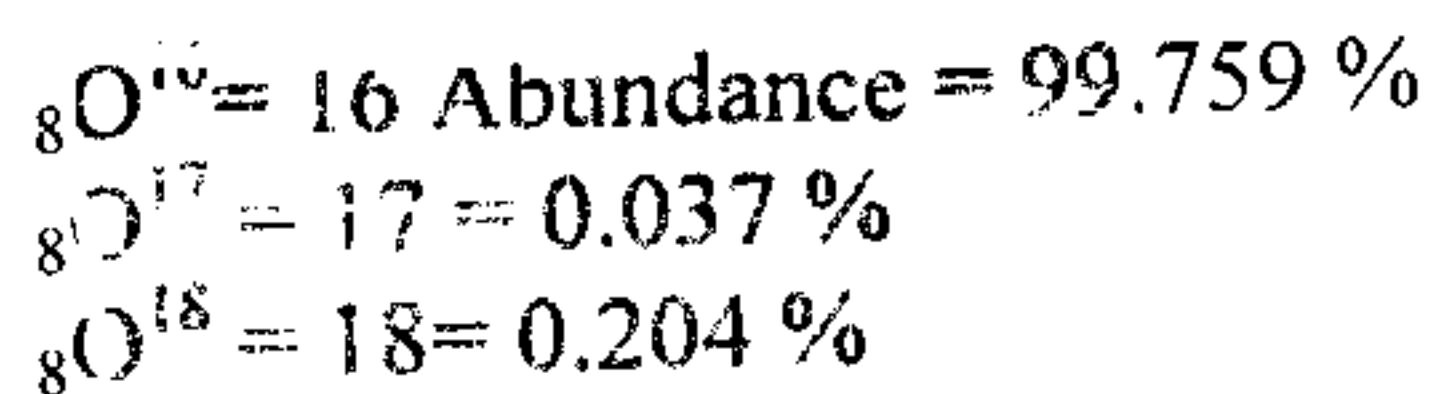
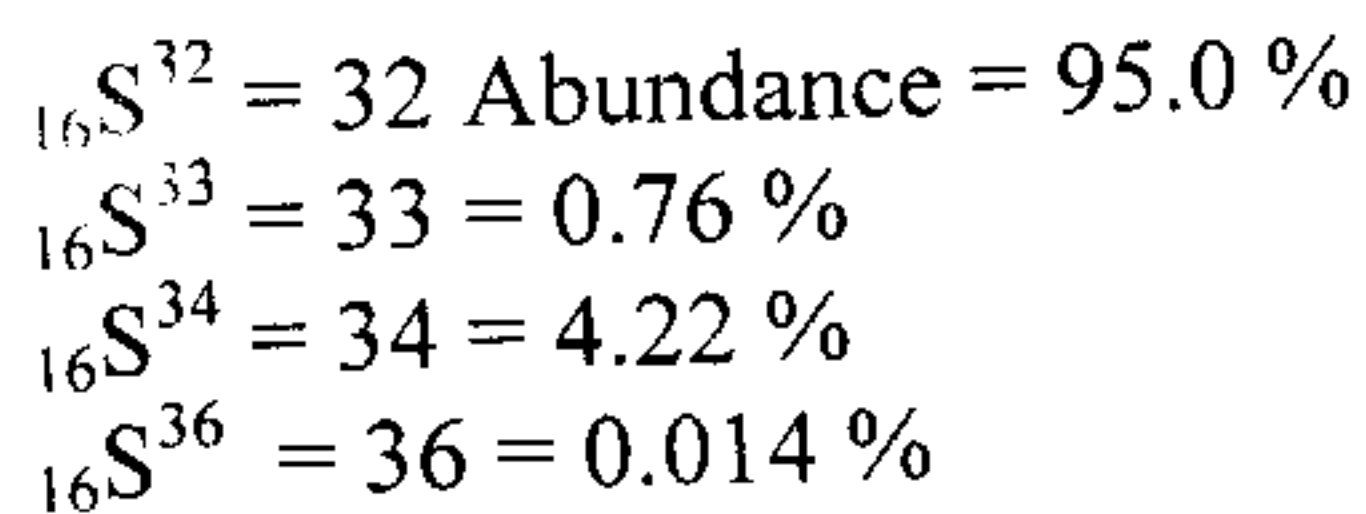
C. **Carbon:-**2 Isotopes.

$_6C^{12}$ = 12 Abundance = 98.893 %
$_6C^{13}$ = 13 = 1.107 %

c) **Oxygen**:- 3 Isotopes.

$_8O^{16}$= 16 Abundance = 99.759 %
$_8O^{17}$ = 17 = 0.037 %
$_8O^{18}$ = 18= 0.204 %

e) **Sulphur** :- 4 Isotopes.

$_{16}S^{32}$ = 32 Abundance = 95.0 %
$_{16}S^{33}$ = 33 = 0.76 %
$_{16}S^{34}$ = 34 = 4.22 %
$_{16}S^{36}$ = 36 = 0.014 %

7. Ask each group to calculate the relative atomic mass of their respective element according to the data provided on the play card.
8. Monitor and help in group works.
9. When each group has completed their work, ask them to present on blackboard.
10. Generalize the group-work.

SUMMARY/MAIN POINTS.

At the end summarize the whole activities in the following points.

1. Atoms are tiny particles of matter (element), which could not be measured, with the help of any analytical balance.

2. Atomic Mass is roughly the sum of Number of protons and Neutrons in the nucleus of an atom.

3. Carbon-12 Atom is choosen as a standard for defining the relative Atomic Masses.

4. Isotopes are atoms of the same element having different Masses.

5. Relative Atomic Mass is defined as average Mass of various Isotopes of an element as compared with carbon-12 atom.

6. Atomic Mass Unit is defined, as a Mass exactly equals to $1/12^{th}$ the mass of carbon-12.

7. 1 atomic Mass Unit = 1.66×10^{-24} grams.
8. Relative Atomic Masses are calculated by: -

$$\text{Relative Atomic Mass} = \frac{\text{Mass of Isotope-1} \times \text{Abundance} + \text{Mass of Isotope-2} \times \text{Abundance}}{100}$$

Self-Assessment.

Q.1 Define the following terms.

(i). Atomic Mass Unit
(ii) Relative atomic Mass
(iii) Isotopes.

Q.2 Calculate Relative Atomic Masses from the following data

(i) Copper $_{29}Cu^{63}$ Abundance = 69.09 % $_{29}Cu^{65}$ Abundance = 30.91 %
(ii) Neon $_{10}Ne^{20}$ Abundance = 90.92 % $_{10}Ne^{21}$ Abundance = 0.26 %

$_{10}Ne^{22}$ Abundance = 8.82 %

Q.3 Prove That: -

1 amu = 1.66×10^{-24} grams.

LESSON NO.2

Concept: - *MOLE AND ITS IMPORTANCE.*

SPECIFIC OBJECTIVES: - At the end of this lesson, the students will be able to: -

(i) Know the meaning of Mole.
(ii) Define Mole
(iii) Tell that Mole is a quantity as well as a number.
(iv) Calculate the Number of Mole from given Masses of Substances.
(v) Know the importance of Mole in Chemistry.

MATERIALS REQUIRED: -

Board, Chalk, A simple Balance made from empty shoe-Polish cane, Iron Nails, Sodium Chloride, water, copper wiring, sugar, weights in gram, play cards showing Mass of substances in grams (5 cards each having 3 values), play cards (5) each having a particular Number of items or figures.

CONTENT/SUBJECT MATTER:

The term Mole has been derived from a Greek word "Moles" meaning "heap", "Pile" or simply "Mass" of a substance.

The amount of matter that contains as many atoms, Ions or molecules as the number of atoms, in exactly 12 grams of carbon-12 Isotope, is the SI Unit of quantity of matter and is known as Mole. A Mole is usually defined as: -

"Atomic weight, Molecular weight or Formula weight of a substance when expressed in terms of Grams".

Mole is a Unit describing certain particular Number just like a Dozen represent 12 Units, an hour representing 60 Minutes or a pair representing 2

individuals. One Mole of any substance always contains a fixed number of particles of that particular substance. This number of particles in one Mole of a substance is 6.02×10^{23} particles and is called Avogadro's Number.

Mole is a quantity as well as a Number. It is Number in the sense because it is always equal to 6.02×10^{23} particles of a given substance. Mole is quantity in the sense that it is always equal to the Atomic weight, Molecular weight or formula weight of a substance in units of grams.

Number of Moles from a given mass of a substance can be determined by simply dividing the given Mass in grams over the Atomic, Molecular or Formula Mass, as the case may be: -

$$\text{Number of Moles} = \frac{\text{Mass in Grams}}{\text{Atomic/Molecular/formula Mass}}$$

EXAMPLES.

MOLES

1. Atomic Mass of H-Atom =1 gm = 1 Mole of Hydrogen = 6.02×10^{23} atoms of Hydrogen.
2. Atomic Mass of Na-Atom = 23gm = 1 Mole of sodium = 6.02×10^{23} atoms of sodium.
3. Molecular Mass of water=2+16=18gm =1 Mole of H_2O = 6.02×10^{23} Molecules of H_2O
4. Formula Mass of Nacl =23+35.5 =58.5 gm =1 Mole of Nacl = 6.02×10^{23} ions of Nacl.

NUMBER OF MOLES.

1. Mass in gms = 58 gm of AI
   At.wt.of AI = 27 gms.
   No. Of Moles =?

$$\text{No. Of Moles} = \frac{\text{Mass in grams}}{\text{Atomic Mass}} = \frac{58}{27} = 2.148$$

No. Of Moles of Aluminum (AI)= 2.148

2. Mass in grams = 26 gms of H_2SO_4

At.wt.of H = 1, At.wt.of S =32, At.wt.of O =16

M.wt.of H_2 SO_4 = 98

No of Moles = ?

No of Moles = $\frac{\text{Mass in grams}}{\text{Molecular Mass}} = \frac{26}{98} = 0.265$

No of Moles of H_2 SO_4 = 0.265

3. Mass in grams = 73 gms of Nacl
At.wt of Na = 23 At.wt of cl =35.5
F.wt of Nacl = 58.5 gm
No of Moles = $\frac{\text{Mass in grams}}{\text{Formula Mass}} = \frac{73}{58.5} = 1.248$
No of Moles of Nacl = 1.248

METHODOLOGY:
Activity No.1

For brain storming, ask the following simple questions:

(i) What is an Atom?
Expected Ans: - The smallest particle of Matter (Element)

(ii). Can you see an Atom with a naked eye?
Expected Ans:- No

(iii). How will you measure such a substance which you cannot see?
Expected Ans: No Reply---- Buzzing.
It is on the basis of last question that you declare to your class that it is possible to measure the amounts of various matters including elements, compounds or formula units of crystalline solids.

Activity No.2 (Meaning and Definition of Moles)

1. The materials required for activity No.2 will be introduced to students
   and placed on table in front of them.
2. Divide the learners into 5 groups.
3. Provide to each group one chemical such as water, sugar and sodium chloride etc.
4. Ask each group to write down the Atomic, Molecular and Formula Masses of the given substances.
5. Now balance, made from shoe-polish cane, is given to each group turn by turn.
6. Ask them to weigh accurately a mass of the given substances equivalent to their Atomic, Molecular and formula Masses.
7. When the students complete their assigned task tell them that the masses they have measured is called one mole of each substance in the language of chemistry.
8. It is here that derive the conclusion about the definition of Mole and write it down on the writing board as:
   " Atomic mass, Molecular Mass or formula mass of a substance expressed in grams is called Mole".
9. Ask the students to write down this definition with yourselves.

Activity No.3 (Mole is a quantity as well as a Number)

1. Provide to each group a play card showing a certain particular Number of items or figures.
2. Ask each group to give a name to your Number of items or figure.
3. The items or figures will include: - 12 Iron nails (Dozen), 250x4 ml water (1 liter) 60 seconds on a watch (I minute), 10 years (A Decade) 10 lacs Rs.(10x1,00,000 = 1,000,000) = (I million Rs.)
4. Ask the group leaders to note down these names on the black board.
5. At this stage, write down the number 6.02×10^{23} or 6,02,000,000,000,000,000,000, 000 on the black board and inquire your students about the name of this number of particles. The response will obviously be negative.

6. Write the name "Mole" for this number of particles and ask them that this number of particles or entities are present in one mole of any substance, according to system international (SI) on the basis of carbon 12 Isotope taken as a standard
7. Explain the concept of Moles with examples and collect these information from the students. Note down these information on black board with the following pattern.
   Atomic weight of H=1 Gram=1 mole of H=6.02×10^{23} atoms of H
   Atomic weight of Na=23 Grams=1Mole of Na=6.02×10^{23} atoms of Na.
   Formula weight of Nacl=58.5 gms=1 Mole of Nacl= 6.02×10^{23} ions of Nacl
   Molecular weight of H2O=18 grams= 1 mole of H_2 O =6.02×10^{23} molecules of H_2O.
8. Generalize the concept that Mole is a quantity as well as a Number.

Activity No.4 (No of Moles)

1. Ask your students:- Can you calculate the Number of Moles from the given Mass of a substance.
   Expected Answer: - No.
2. Write down the formula on blackboard and ask the students to note it down with yourselves. The formula is
   $$\text{No of Mole} = \frac{\text{Mass in grams}}{\text{Atomic mass/Molecular Mass/Formula Mass}}$$
3. Distribute to each group one-play card.
4. The play will have a Mass in gram of a substance and the Atomic/Molecular/Formula mass of that substance e.g. 60 grams calcium (Ca)/atomic Mass of Ca=40 gm. 37 grams of H_2 O/ Molecular Mass of H_2 O= 18 gm.
5. Ask them to calculate the number of Moles from the values on play Card.
6. Note down each group response on black board.
7. In the end, generalize all the group responses according to the given formula and respective masses.